

EXPERIMENTAL AND THEORETICAL STUDIES OF ICE-ALBEDO FEEDBACK PROCESSES IN THE ARCTIC BASIN

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LONG TERM GOALS

The overall goal of our proposed work is to develop a quantitative understanding of the processes that collectively make up the ice-albedo feedback mechanism.

OBJECTIVES

To achieve this goal, we must first determine how shortwave radiation is distributed within the ice-ocean system, then assess the effects of this distribution on the regional heat and mass balance of the ice pack. Specifically we wish to determine:

- How is shortwave radiation partitioned between reflection, surface melting, internal heat storage, and transmission to the ocean, and
- How is this partitioning affected by the physical properties of the ice, snow cover, melt ponds and the distribution of particulates?
- What is the areal distribution of ice, ponds, and leads,
- How does this distribution vary with time, and
- What is the impact on area-averaged heat and mass fluxes?
- What are the crucial variables needed to characterize ice-albedo feedback processes and their effect on the heat and mass balance of the ice pack, and
- How accurately can the ice-albedo feedback processes be treated through simplified models and parameterizations?

APPROACH

These objectives will be addressed through a combination of field observations and theoretical modeling. We will participate in the SHEBA field experiment for its full 13 month duration. Activities during the first fall will involve selecting the primary floe, surveying the floe, selecting measurement sites and deploying instrumentation. Continuously recording instrument packages will be deployed at several time series measurement (TSM) sites where ice temperature profiles, ice growth rates and snow depths will be routinely monitored. Numerous hot wire thickness gauges will be installed at other sites on the floe, one important objective being to measure growth rates across one or more pressure ridge keels. Routine observations carried out

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during the winter will be aimed at quantities needed to estimate the ice thickness distribution and area-averaged heat and mass fluxes. Activity will increase in the spring with the deployment of optical sensors in the ice at the TSM sites plus detailed snow studies, ice properties work, and optical measurements. The spring effort will be directed towards defining the initial conditions at the onset of melt. Summer observations will focus on measuring the temporal evolution and spatial variability of such quantities as albedo, light absorption in the ice, transmittance, mass balance and pond coverage. During the second fall, measurements will continue at the TSM sites, along with studies of changes in albedo due to snowfall and freeze-up of the ice, leads and melt ponds.

We plan to apply information obtained from local process and time evolution studies to the estimation of areally-integrated heat and mass fluxes. For this purpose, numerous surveys will be conducted to give us a statistical picture of the spatial variability within individual ice types, and provide quantitative information on the fractional area covered by these categories within the SHEBA region. Surface-based surveys will be conducted routinely during the spring and summer to sample albedo, snow and ice properties, melt pond depth and area, surface topography and lead temperatures. Frequent helicopter surveys will be conducted throughout the summer to look at local and larger-scale variations in ice concentration, melt pond fraction, floe size distribution, floe perimeter and surface reflectivity. Such data will play an important part in obtaining regional estimates of shortwave input to the ocean, lateral melting on floe edges and melt pond effects.

Process-oriented modeling will supplement and augment the field studies. Field data on ice structure and optical properties will be combined with laboratory data to develop and verify a model that relates structural and optical properties in warm sea ice. Such a model is needed in any advanced treatment of radiative transfer in sea ice and will form the basis for modeling efforts to predict the optical evolution of the ice cover during the summer melt season. We will also carry out a theoretical investigation of how reduced ice growth beneath melt ponds affects their impact on the regional mass balance. Other models will be used to generalize observational results on lateral melting and floe size distribution, and to evaluate possible effects of soot released from the ship on albedos, melting and heat fluxes.

ACCOMPLISHMENTS

Our efforts to date on this project have focused on preparing for the SHEBA field program that began in September 1997. We have conducted extensive planning and preparation for this year-long experiment. This preparation has included developing an autonomous datalogging system to measure ice temperature and mass balance. Ten of these systems have been built for use during SHEBA. We have also fabricated such equipment as 150 ablation stakes and the mechanical hardware needed to make albedo and transmittance measurements of the ice cover. The equipment has been transferred to the NGCC Des Groseilleirs for shipment to the SHEBA field site. We are presently involved in the deployment of the SHEBA ice station.

SCIENTIFIC/TECHNICAL RESULTS

This project started in May 1997 and does not yet have any technical results.

IMPACT FOR SCIENCE / SYSTEMS APPLICATIONS

Results from this work will help improve sea ice models used for ice forecasting and general circulation models used in climate studies. In particular, more accurate parameterizations of sea ice radiative transfer will result from these studies

TRANSITIONS

During the few months of this project the focus has been on the SHEBA field experiment. We have made the transition from the planning stage to beginning the measurement program.

RELATED PROJECTS

This work is being performed in close cooperation with other SHEBA investigators funded by ONR and NSF. In particular we are working closely with G.A. Maykut and T.C. Grenfell (ONR Contract N00014-97-1-0765) on this program.

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Perovich, D.K. and W.B. Tucker III, Arctic sea ice conditions and the distribution of solar radiation during summer, submitted in June 1996 to *Annals of Glaciology*, in press.